FIG 1

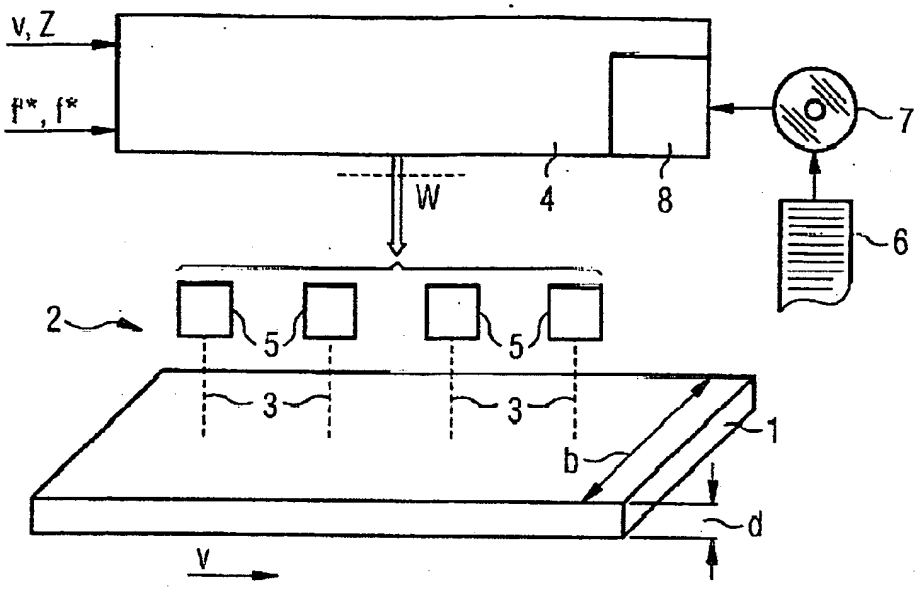


FIG 2

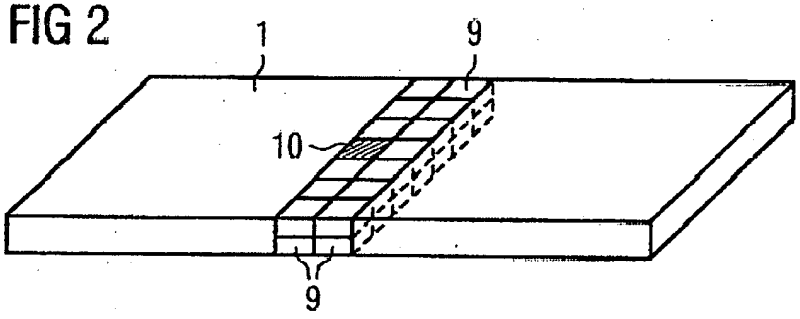


FIG 3

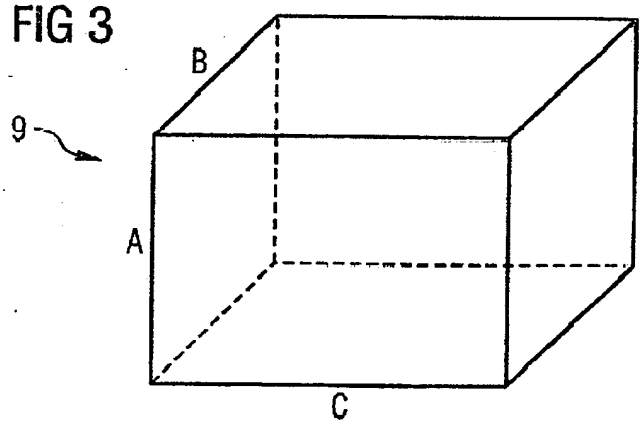


FIG 4

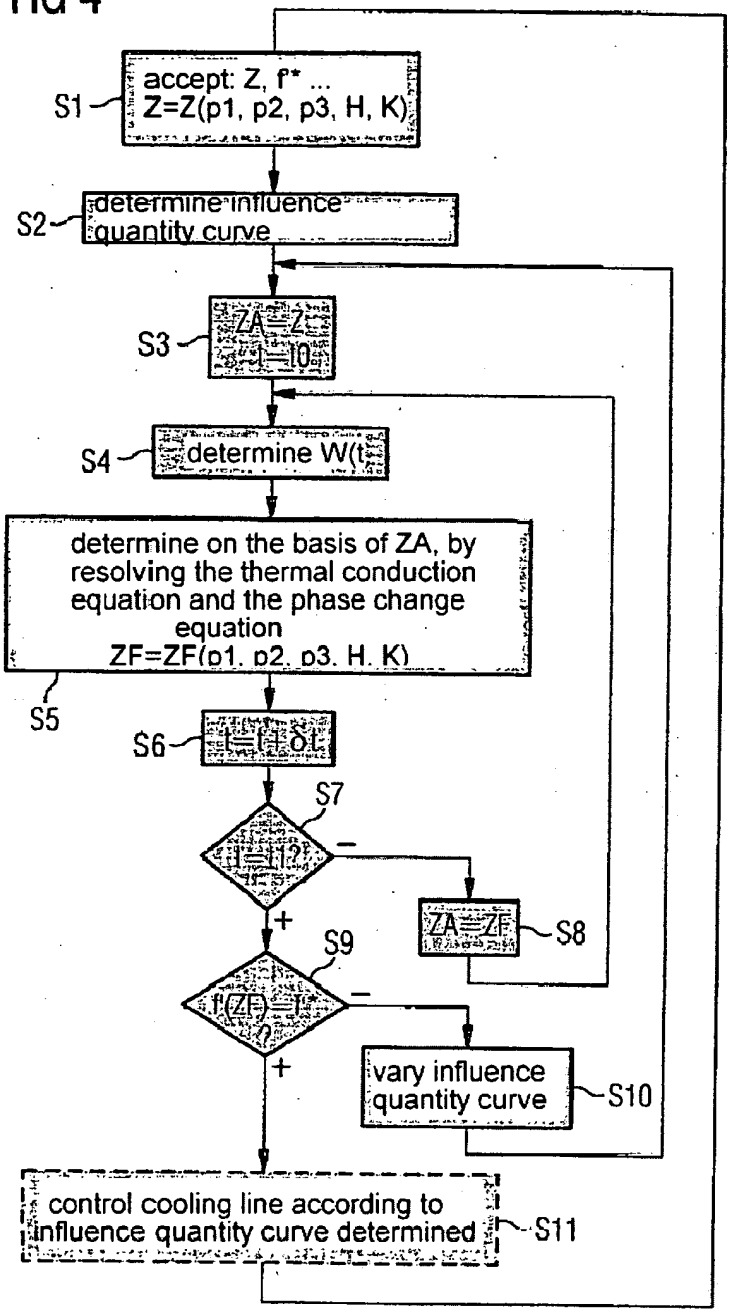

S1
accept: Z, f* ...
Z=Z(p1, p2, p3, H, K)
S2
determine influence quantity curve
S3
ZA=Z
i=10
S4
determine W(t
determine on the basis of ZA, by resolving the thermal conduction equation and the phase change equation
ZF=ZF(p1, p2, p3, H, K)
S5
S6
t=t+δt
S7
t=t1?
+
−
S8
ZA=ZF
S9
f(ZF)=f*
?
+
−
S10
vary influence quantity curve
S11
control cooling line according to influence quantity curve determined

FIG 5

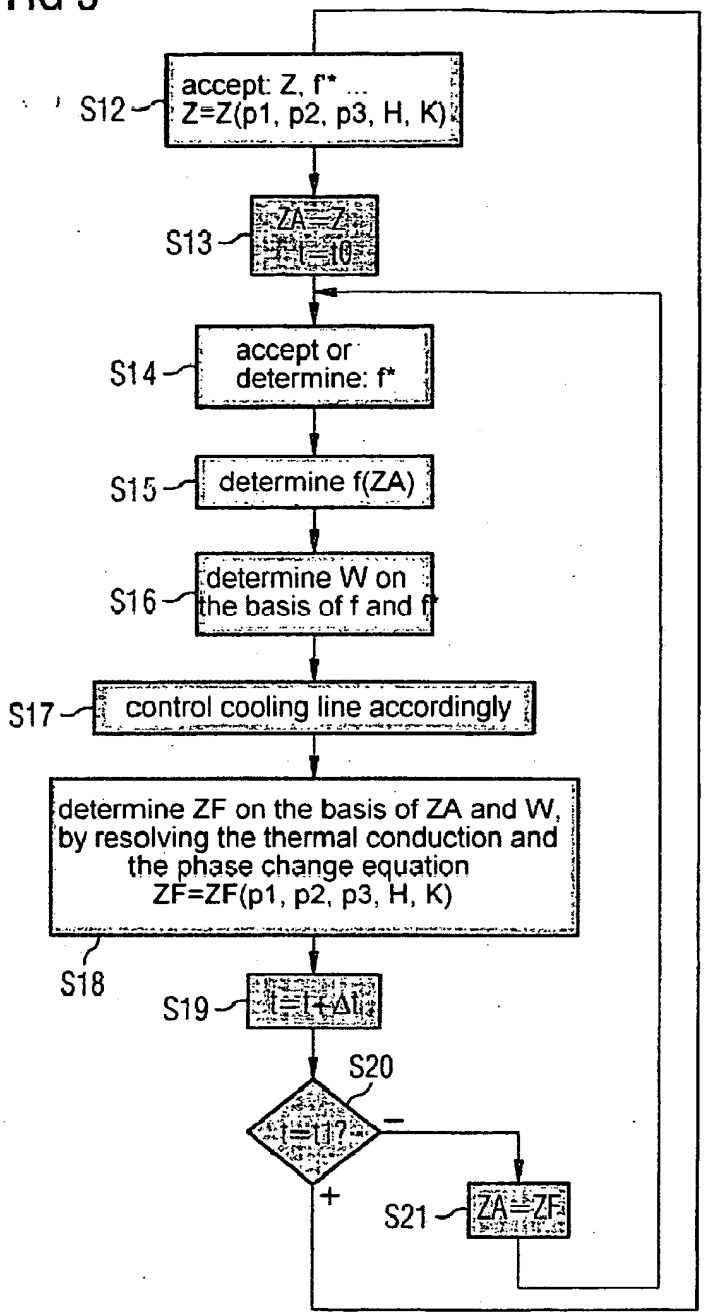

S12
accept: Z, f* ...
Z=Z(p1, p2, p3, H, K)
S13
ZA=Z
t=t0
S14
accept or
determine: f*
S15
determine f(ZA)
S16
determine W on
the basis of f and f*
S17
control cooling line accordingly
determine ZF on the basis of ZA and W,
by resolving the thermal conduction and
the phase change equation
ZF=ZF(p1, p2, p3, H, K)
S18
S19
t=t+Δt
S20
t=t1?
−
+
S21
ZA=ZF

FIG 6

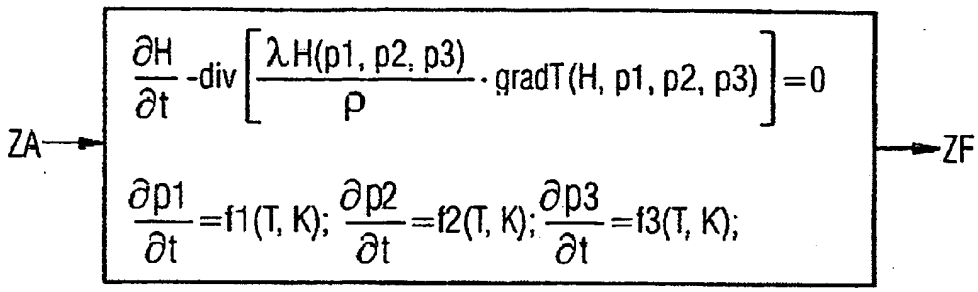

ZA
$\frac{\partial H}{\partial t} - \mathrm{div}\left[\frac{\lambda H(p1, p2, p3)}{\rho} \cdot \mathrm{grad}T(H, p1, p2, p3)\right] = 0$
$\frac{\partial p1}{\partial t} = f1(T, K); \frac{\partial p2}{\partial t} = f2(T, K); \frac{\partial p3}{\partial t} = f3(T, K);$
ZF

FIG 7

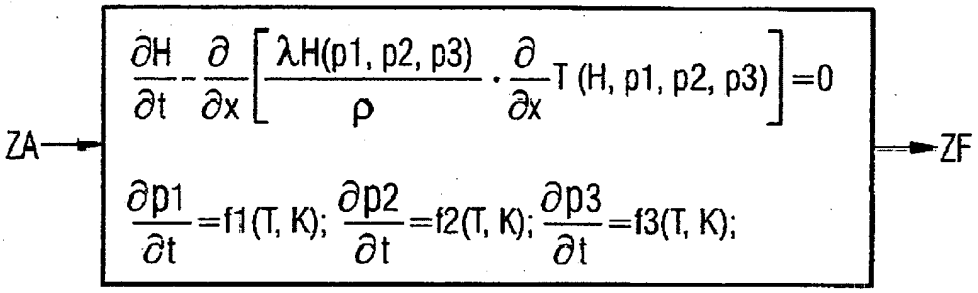

ZA
$\frac{\partial H}{\partial t} - \frac{\partial}{\partial x}\left[\frac{\lambda H(p1, p2, p3)}{\rho} \cdot \frac{\partial}{\partial x} T(H, p1, p2, p3)\right] = 0$
$\frac{\partial p1}{\partial t} = f1(T, K); \frac{\partial p2}{\partial t} = f2(T, K); \frac{\partial p3}{\partial t} = f3(T, K);$
ZF

FIG 8

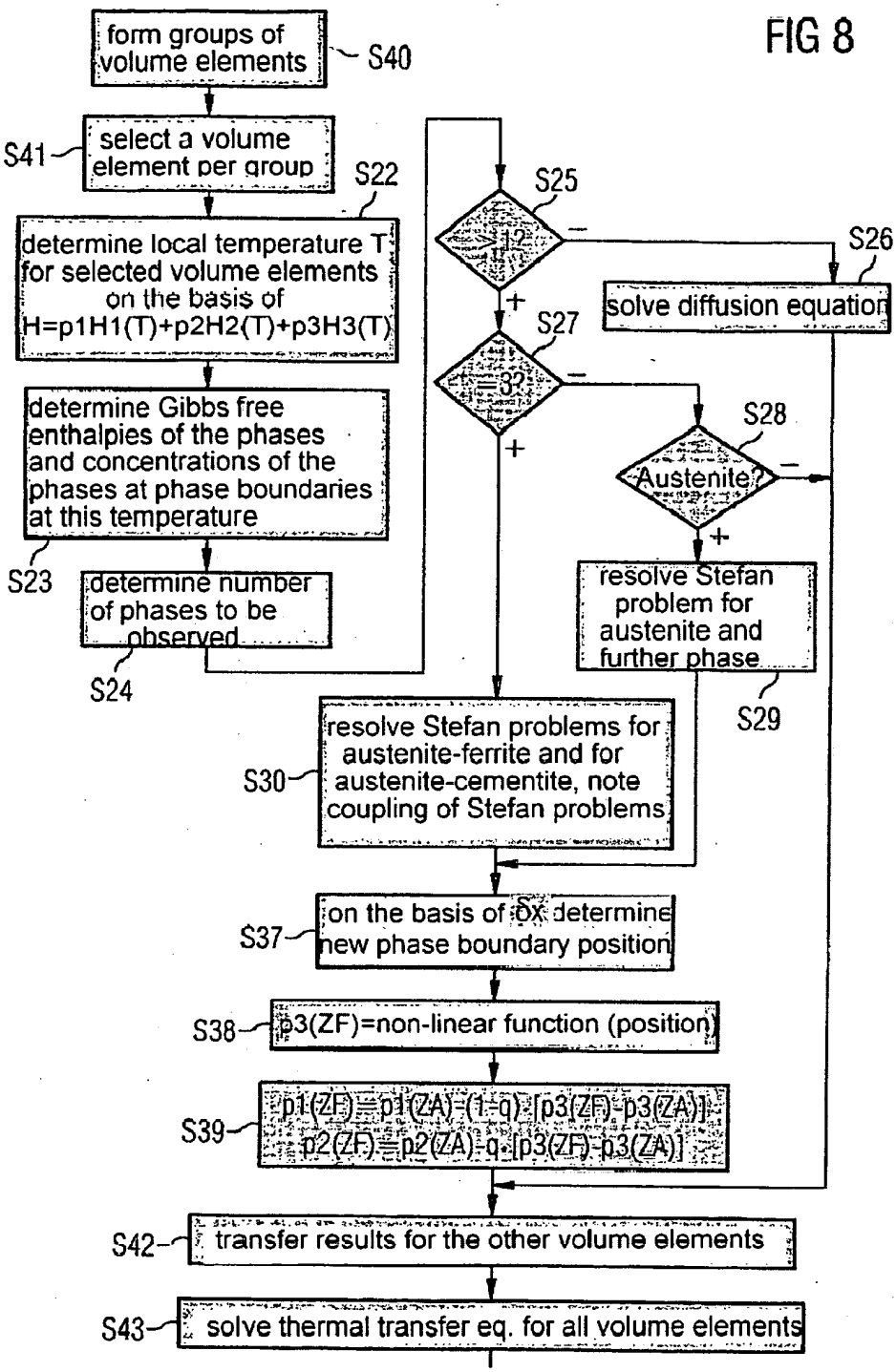

form groups of volume elements
S40
S41
select a volume element per group
S22
determine local temperature T for selected volume elements on the basis of H=p1H1(T)+p2H2(T)+p3H3(T)
determine Gibbs free enthalpies of the phases and concentrations of the phases at phase boundaries at this temperature
S23
determine number of phases to be observed
S24
S25
>1?
S26
solve diffusion equation
S27
=3?
S28
Austenite?
resolve Stefan problem for austenite and further phase
S29
resolve Stefan problems for austenite-ferrite and for austenite-cementite, note coupling of Stefan problems
S30
on the basis of δx determine new phase boundary position
S37
S38
p3(ZF)=non-linear function (position)
S39
p1(ZF)=p1(ZA)+(1-q)·[p3(ZF)-p3(ZA)]
p2(ZF)=p2(ZA)-q·[p3(ZF)-p3(ZA)]
S42
transfer results for the other volume elements
S43
solve thermal transfer eq. for all volume elements

FIG 9

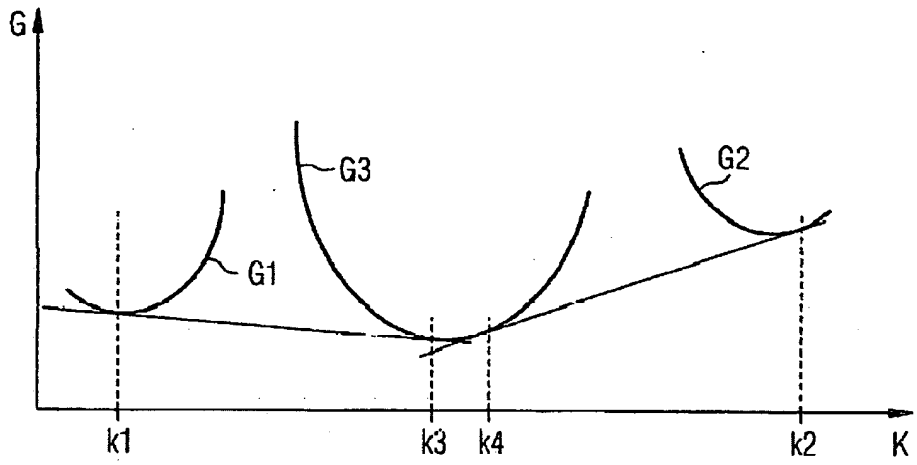


FIG 10

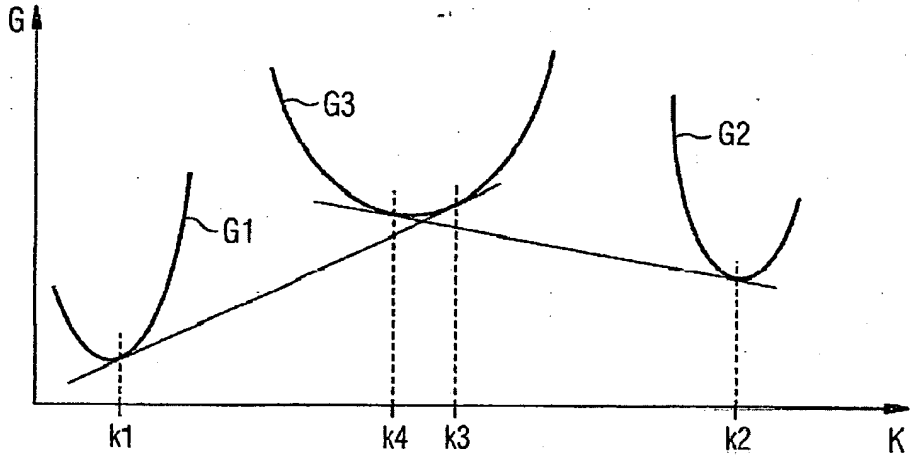


FIG 11

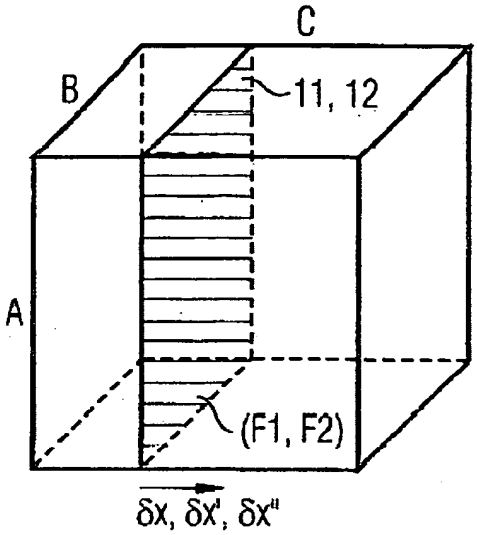


FIG 12

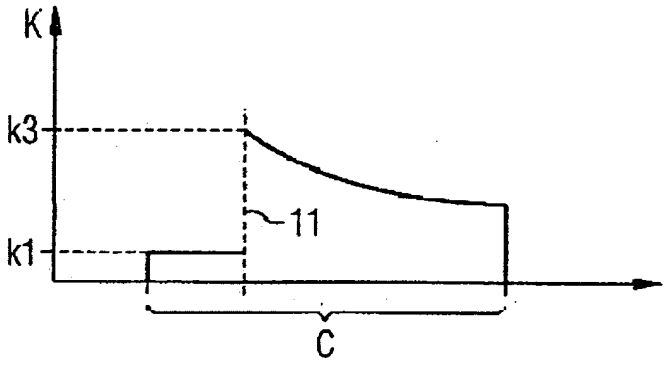


FIG 13

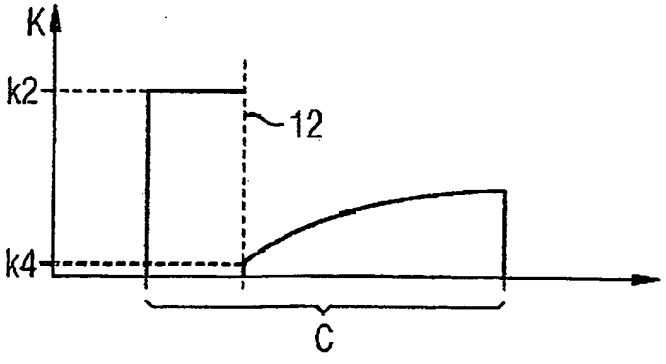


FIG 14

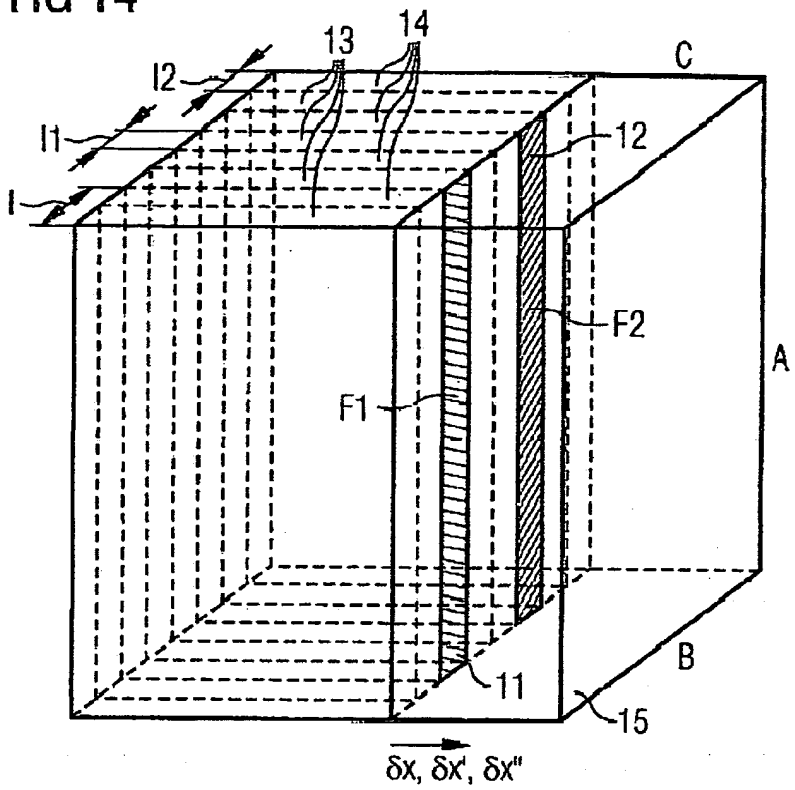

13
14
C
I2
I1
I
12
F2
A
F1
B
11
15
δx, δx', δx''

FIG 15

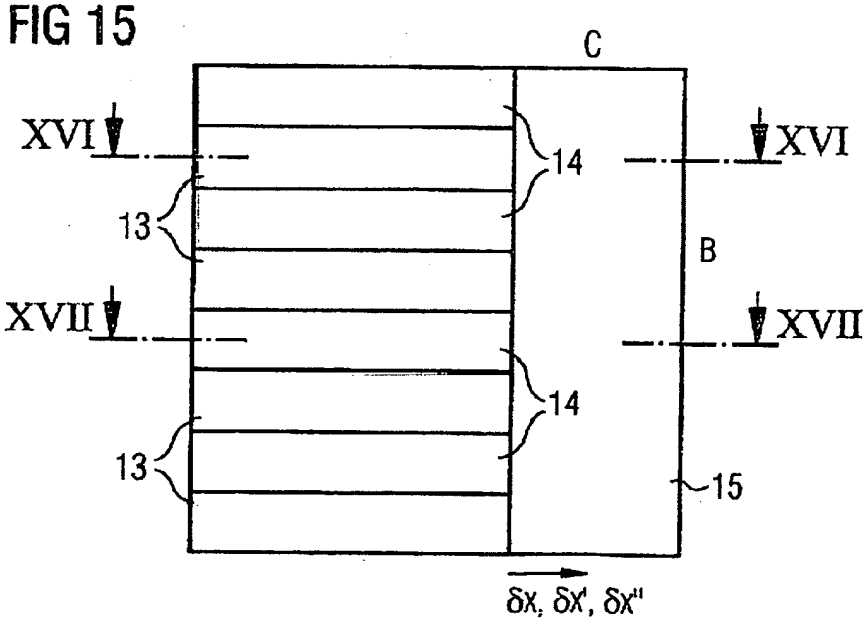

C
XVI
14
XVI
13
B
XVII
XVII
14
13
15
δx, δx', δx''

FIG 16

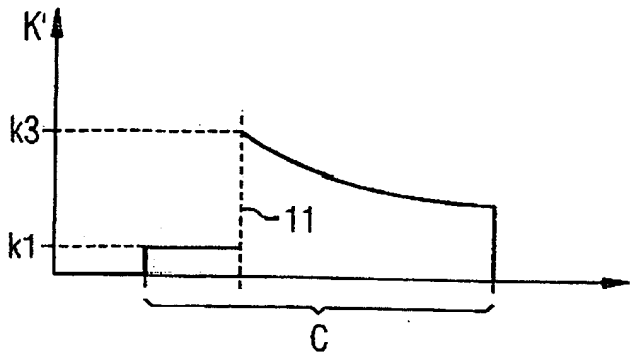


FIG 17

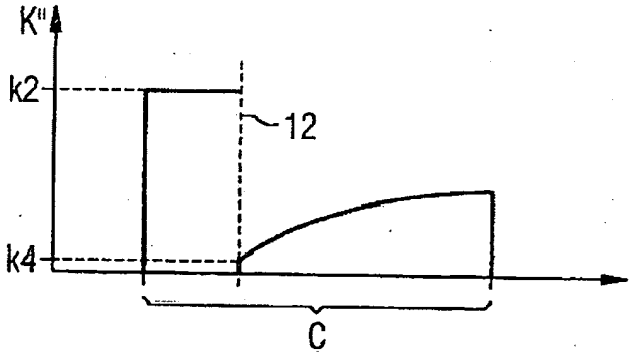


FIG 19

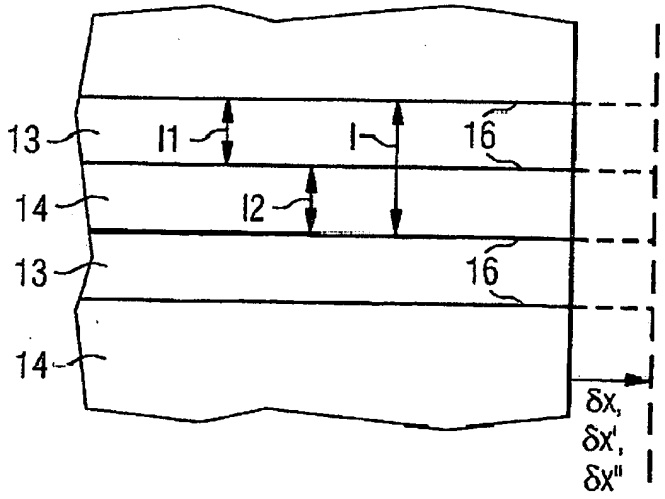
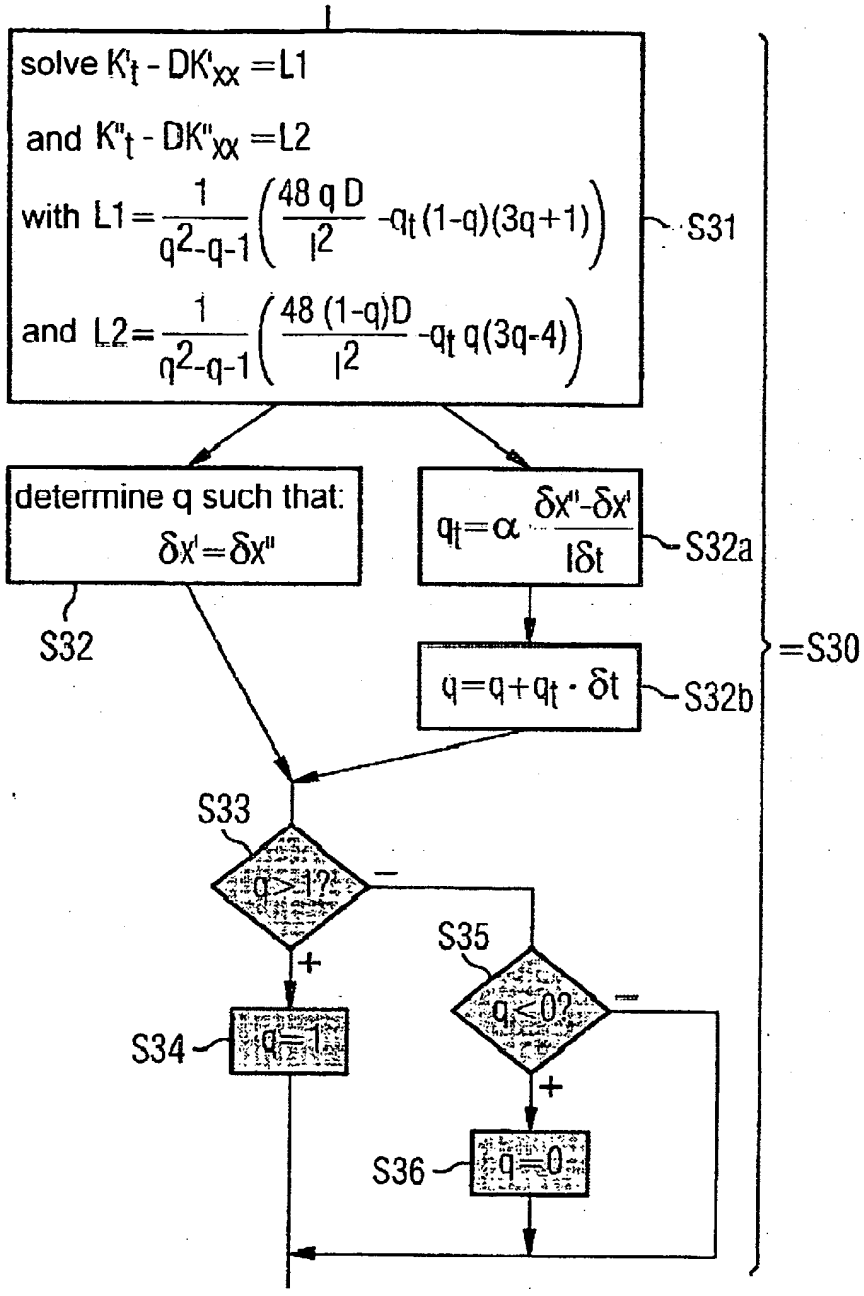


FIG 18


solve K't - DK'xx =L1
and K"t - DK"xx =L2
with L1 = 1/(q2-q-1) (48 q D/l2 -qt (1-q)(3q+1))
and L2 = 1/(q2-q-1) (48 (1-q)D/l2 -qt q(3q-4))
S31
determine q such that:
δx'=δx"
S32
qt=α δx"-δx'/lδt
S32a
q=q+qt · δt
S32b
=S30
S33
q>1?
+
−
S34
q=1
S35
q<0?
+
−
S36
q=0